NRMC- 82
WG2/65
20 September 1994

REPORT OF WORKING GROUP 2 TO THE LMDS/FSS 28 GHz BAND NEGOTIATED RULEMAKING COMMITTEE

Robert James, Chairman, Working Group 2

SECTION I:

INTRODUCTION

The Commission established this negotiated rulemaking committee to determine the feasibility of co-frequency sharing between LMDS and FSS in the 27.5-29.5 GHz ("28 GHz") band. Working Group 2 was created to assess the possibility of co-frequency sharing between Non-GSO MSS feeder links and LMDS systems proposing to operate in this band. This Report concludes that sharing of the 28 GHz band is possible with the imposition of some restrictions on both Non-GSO MSS and LMDS operators. It is noted that during this proceeding, only one Non-GSO MSS applicant definitively indicated an intent to establish feeder links in this part of the spectrum.

On the basis of its work, Working Group 2 reached the following principal conclusions:

(1) Unrestricted sharing of the band is not possible due to the interference level anticipated from LMDS backbone and subscriber transmitters into Non-GSO MSS feeder link receivers, and due to the interference level anticipated from Non-GSO MSS feeder link transmitters into LMDS receivers. The orbital design of the satellites associated with these feeder links results in LMDS subscriber transmitter antenna look angles being on boresight with the satellite receivers. To minimize the potential interference problem, the group recommends that an EIRP limit be placed on LMDS backbone point-to-point microwave links, and that the power spectral density radiated toward the horizon by LMDS hubs not exceed the level which would result in unacceptable interference into a Non-GSO MSS satellite receiver. Working Group 2 also recognized that interference from LMDS subscriber terminals was a significant issue which required mitigation measures. One option discussed was that subscriber transmitters be precluded from operating in the band [29.1 - 29.5 GHz].

(2) A coordination procedure is required to assist in precluding unacceptable interference from Non-GSO MSS feeder link systems to LMDS receivers. One

option discussed was a rule to require that Non-GSO MSS feeder links be located at an appropriate distance from the boundary of certain metropolitan statistical areas. There remains the need for operators of these systems to have access to information to enable them to maximize their use of the spectrum.

(3) Motorola is the only potential Non-GSO MSS operator proposing to use spectrum in the 27.5 - 29.5 GHz band for feeder link transmissions. Three other potential Non-GSO MSS operators have requested feeder link spectrum below 15 GHz, and one has requested feeder link spectrum at 29.5-30.0 GHz. Attempts to accommodate other Non-GSO MSS operators' feeder link requirements in the 28 GHz band would greatly complicate the sharing environment between Non-GSO MSS feeder links as well as between Non-GSO MSS feeder links and the LMDS service.

Motorola Satellite Communications, Inc. and Suite 12 reached an agreement that they believe permits a variety of LMDS systems and a limited number of Non-GSO MSS service providers to effectively share the 28 GHz band. The product of those negotiations served as the basis for a discussion of the rules and recommendations the group is submitting to the full Committee.

Working Group 2's (WG2) assignments in this proceeding are outlined in the LMDS/FSS 28 GHz Band Negotiated Rulemaking Committee's work program (NRMC-8 (Rev. 1)) as follows:

Provide recommendations for the formulation of technical regulations for the Local Multipoint Distribution Service (LMDS) and/or the Non-GSO Mobile Satellite Service (MSS), so as to maximize the co-frequency sharing of the 27.5 - 29.5 GHz frequency band between these services. WG2 shall analyze the potential interference problems between LMDS systems and feeder links for Non-GSO MSS services.

Provide advice concerning the technical and coordination issues presented by co-frequency sharing between these two services.

Recommend technical rules that should be adopted. (All recommendations or [redacted]

1.1 Work Plan

To accomplish its work, Working Group 2 used the following approach:

1. Assembled data on proposed LMDS and Non-GSO MSS systems.

2. Developed outline of approach to work:

   a. Agreed on the structure of the link-budget calculations, i.e., list the parameters that enter the calculations;

   b. Agreed on ranges for those parameters where the precise values cannot be agreed to;

   c. Performed calculations of link budget and quantify interference effects considering the relevant output of the technical sub-work group; and

   d. Listed possible resolutions of interference problems along with their advantages and disadvantages.

3. Performed analyses on the following sharing/compatibility cases:

   a. Non-GSO MSS feeder uplink earth stations associated with satellites providing mobile satellite services in the 1610 - 1626.5/2483.5 - 2500 MHz bands causing potential interference to LMDS system components (e.g., hub stations, repeaters, and subscriber terminals); and

   b. LMDS system components causing potential interference on an individual LMDS station basis or as an aggregate of all visible LMDS terminals and hub stations to Non-GSO MSS feeder links operating in the 28 GHz band.

4. Developed proposed rules and policies that will permit co-frequency sharing in the 28 GHz band between the two services.

1.2 Working Group Structure and Assignment of Tasks

Initially, the two working groups established by the NRMC met jointly for 11 meetings to minimize the number of times system proponents would present their system characteristics, unique features, operational procedures and technical parameters. The working groups also took advantage of this time to develop systematic approaches to resolve assigned tasks. To assist this process, the joint groups created a Joint Technical Sub Group to research and advise the working groups on 12 subject matters. The results of this group were used in completing the required interference analyses. Once the work of the JTSG was completed, the working groups began to meet as separate units.

Working Group 2 created two ad hoc committees. After receipt of the agreed to system technical parameters, several members of Working Group 2 volunteered to serve on an ad hoc committee to perform computations. (Scott Seidel of Bellcore chaired the group.) This committee, the Computation and Analysis Ad Hoc Committee, completed a number of studies. Sharing studies were also submitted by individual members of the Working Group. From these calculations, Working Group 2 assessed the magnitude and the difficulty of co-frequency sharing between Non-GSO MSS feeder links and LMDS systems.

The second committee, entitled the Report Drafting Ad Hoc Committee and chaired by Stephen Baruch, undertook the task of assembling this report to the full Negotiated Rulemaking Committee. Each participating member developed a specific segment of the report.

1.3 Working Group Meetings and Participation

During the life of this Committee, Working Group 2 met 9 times with an average participation of 20 persons. Meetings were held on August 16, 18, 23 and 26; September 1, 8, 10, 15, and 17, 1994. The list of participants in the working group and each of its ad hoc committees are listed in Attachment A, and the list of documents considered by Working Group 2 is presented in Attachment B.

SECTION II:

DESCRIPTIVE SYSTEM CHARACTERISTICS

2.1 General Descriptions Of LMDS Systems

The Local Multipoint Distribution Service (LMDS) is a two-way point-to-multipoint and multipoint-to-point service operating in the 27.5-29.5 GHz millimeter wave frequency range. As proposed, two licenses would be granted in each Basic Trading Area (BTA) as defined by Rand McNally, one at 27.5-28.5 GHz band and one at 28.5-29.5 GHz. Path lengths are relatively short at this frequency range, and each licensee could employ frequency reuse techniques (e.g., antenna directionality, polarization isolation, frequency offset) so that the same 1000 MHz of spectrum would be used to provide service within the licensee's service area.

The Negotiated Rule Making Committee and its Working Groups considered LMDS system designs provided by three entities: Suite 12/CellularVision; VideoPhone/Endgate; and Texas Instruments. These three system designs are similar in that they all employ a cellular design, with frequencies being reused at each cell. However, each system design is unique in some aspect. The three designs analyzed are described generally below. Section V provides all the detailed parameters used in the analysis.

a. Suite 12/CellularVision™

The Suite 12/CellularVision design, which is currently operational, is intended primarily to provide a video distribution service, with two-way voice and data capability also available. It consists of 49 channels of frequency modulated video. Two-way voice and data signals are carried in the interstitial frequency spaces between video channels. A typical cell size is 4.8 km radius. Each cell employs an omnidirectional or wide-beam antenna. Each subscriber location employs a highly directional antenna. Isolation between hub transmissions in adjacent cells is achieved by cross-polarization isolation, frequency interleaving and the directionality of the subscriber antenna. Two-way voice and data transmissions are carried at data rates of 16 kbit/sec to 1.544 Mbit/sec. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	FM video	Digital
Output Power	-5 dBW	-32 to -12 dBW
Antenna Gain	12 dBi	31 dBi
Bandwidth	18 MHz	0.01 to 1 MHz
Cell Radius	4.8 km	4.8 km

b. VideoPhone/Endgate

The VideoPhone/Endgate LMDS architecture incorporates optional AM, FM, and digital modulation configurations to provide a variety of one-way and two-way voice, data, and video services. Hub density, intended cell coverage radius, the degree of cell sectorization, EIRP levels, and other parameters in a typical VideoPhone/Endgate deployment will vary according to service demand and interference environment conditions. VideoPhone/Endgate may also employ hub diversity in some deployments to allow users to orient antennas toward multiple hub locations, as well as dynamic channel assignment and other operational capabilities. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	Digital	Digital
Output Power	-70 to -17.3 dBW	-78 to -9 dBW
Antenna Gain	29.7 dBi	38 dBi
Bandwidth	6 to 20 MHz	1.5 to 100 MHz
Cell Radius	0.8 km	0.8 km

c. Texas Instruments

The Texas Instruments design consists of several digital alternatives as well as FM video and AM video. A typical cell size is 5.0 km radius (1.0 km for AM video), but cells overlap so a typical hub-to-hub distance would be 5.0 km. Each cell employs an omnidirectional or wide-beam antenna. Each subscriber location employs a highly directional antenna. Isolation between hub transmissions in adjacent cells is achieved by the directionality of the antennas and cross-polarization isolation. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	Digital, FM video	Digital
Output Power (per channel)	0 to -22 dBW	-12 to -32 dBW
Antenna Gain	15 dBi	35 dBi
Bandwidth	5.2 to 52 MHz	5.2 to 52 MHz
Cell Radius	5.0 km	5.0 km

2.2 General Descriptions Of MSS Feeder Links

The service links of most current and proposed communications satellites intended for operation with mobile terminals employ frequencies below 3 GHz. Most spacecraft in the Mobile Satellite Service (MSS) connect the mobile earth terminal (MET) to a fixed earth station or gateway for interfacing the link to a terrestrial switched network, either public or private. Most MSS systems employ frequencies allocated to the Fixed Satellite Service (FSS) for the feeder links between the MSS spacecraft and gateways.

Most MSS spacecraft operating in the GSO have opted to employ FSS allocated spectrum in C- or Ku-bands for feeder links. However, of the five recent U.S. applicants for Non-GSO MSS systems, two have proposed the use of Ka-band frequencies for their feeder links. One proposed Non-GSO MSS system, Motorola's IRIDIUM, proposes to employ the 29.1-29.3 GHz band as a feeder and satellite control uplink and the other, TRW's Odyssey™, proposes to use a portion of the 29.5-30.0 GHz band for its Earth-to-space feeder link transmissions. The other U.S. Non-GSO MSS applicants propose to employ portions of C-band and Ku-band for their feeder links. However, it appears that access by these proposed systems to their applied-for feeder link spectrum may not be possible, and the FCC has advised consideration of alternate bands, such as Ka-band.

REPRESENTATIVE 20/30 GHz BAND TECHNICAL CHARACTERISTICS: TRW INC. ODYSSEY™ SYSTEM

PARAMETER	CHARACTERISTIC
1. ORBITAL PARAMETERS	
No. of Planes/No. of Satellites per Plane	3 planes/4 satellites per plane
Spacing of Planes/Phasing of Planes	120°/30°
Inclination/Orbital Period	50°/6 hours
Apogee/Perigee	10354 Km/10354 Km
Right Ascension/Argument of Perigee	Variable/0°
2. FREQUENCY BANDS (FEEDER LINK ONLY)	
Uplink (Earth Station to Satellite)	W/in 29.5-30.0 GHz
Downlink (Satellite to Earth Station)	W/in 19.7-20.2 GHz
3. CARRIER TRANSMISSION PARAMETERS	
Multiple Access Technique	FDMA/CDMA
Modulation Types	Filtered OQPSK
Information Data Rate (per user)	4.80 Kbps
Coded Data Rate (Convolutional Rate = 1/3, k=7)	14.40 Kbps
Assigned BW Each Carrier	2.50 MHz
Assigned Channel Spacing (Center-to-Center)	2.75 MHz
Required [C/(N+I)] (Satellite-to-Earth Station)	
Clear Sky	65.23 dB Hz
Rain (10 dB rain loss)	52.81 dB Hz
Interference Criteria is Delta-T/Ts(%)	< 6%/Meets ITU Rad. Reg.' 1990:App. 29, ORB-88
Transmitter Noise, C/N (dB)	>30 dB
Transmitted RF Power (Input to Antenna)	21.40 dBW
Uplink Power Density	-20.90 dBW/4 kHz
Uplink Transmitted EIRP per User (including Antenna Gain)	54.25 dBW
Downlink Transmitted EIRP per User (including Antenna Gain)	22.80 dBW
Satellite Noise Figure	8.00 dB
Satellite Total System Noise Temperature	1830.00°K (or 32.6 dB/°K)
Earth Station Noise Figure	3.40 dB
Earth Station Total System Noise Temperature (including Rain)	666.50°K (or 28.2 dB/°K)
4. SATELLITE ANTENNA PARAMETERS	
No. of Spot Beam/Pointing Direction from Nadir	3 independent steerable spot beams
Transmitted Antenna Peak Gain/Beamwidth/Polarization	36.0 dBi/2.58°/RHCP
Received Peak Gain/Beamwidth/Polarization	39.5 dBi/1.73°/LHCP
Sidelobe Mask	ITU Appendix 29, WARC-ORB-88
5. EARTH STATION ANTENNA PARAMETERS	
Service Min. Elevation Angle/Steerable	10° Elev. Angle/Steerable Antenna
Transmitted Antenna Peak Gain/Beamwidth/Polarization	64.85 dBi/0.11°/LHCP
Received Antenna Peak Gain/Beamwidth/Polarization	60.80 dBi/0.17°/RHCP
Sidelobe Mask	Meets 47 CFR 25.209 (29-25Log(delta), delta=angle of axis)
No. of Earth Stations and Distribution (minimum)	7 Earth Stations (global coverage)
CONUS Earth Stations	2 Earth Stations
North American Satellite Control Stations	3 Earth Stations

For additional information, contact: Eric Wiswell, TRW Inc. 310-812-0665
Richard Barnett, Telecomm Strategies, 301-229-0204

Technical Characteristics
for
Ka-Band Feeder Link (Earth to Space)

<u>General Parameters</u>

Orbit	
Types	Borealis Concordia
Borealis	
Number of planes/satellites	2 planes/4 sat
Inclination	116.3 degrees / 64
Apogee/perigee	7846/520 Km
Minimum Elevation Angle (working)	10 (US)
(non working)	5 (US)
Concordia	
Number of planes/satellites	1 plane/6 satellites
Inclination	0 degrees
Apogee/perigee	7846 Km Circular
Minimum Elevation Angle (working)	10 (US)
(non working)	5 (US)

Technical Parameters (continued)

Frequency Bands

Service	Earth to Space		1.6 Ghz
	Space to Earth		2.4 Ghz
Feeder Link Earth to Space		Desired	C-Band
		Analysis	Ka-Band (27.5/29.5 Ghz)
Feeder Link RF Bandwidth			300 Mhz (or 600)
RF Channel Bandwidth			16.5 Mhz
Polarization			Cir.

Earth Station

Antenna size	5m
Antenna Beamwidth (1)	0.15 degs.
Gain	61 dB
HPA size	100W (at feed)
eirp per channel	62.5 dBw
Number of channels (per 8.25 Mhz)	63
eirp per 8.25 Mhz	80.5 dBw

(1) Sidelobes FCC Rules 25.209

Technical Parameters (continued)

Up Link

Condition	Clear	Wide Spread Rain [1]
eirp per channel	62.5 dBw	62.5 dBw
Path Loss	200 dB	200 dB
Atmospheric Loss	1 dB	10 dB
Satellite G/T		
Temp	1000 K	1000 K
Ant. BW	60 degs	60 degs
Ant. Gain	8.5 dB	8.5 dB
G/T	-21.5 dB/K	-21.5 dB/K
C/No	68.7 dB/Hz	58.7 dB/Hz
Interference Allowance	6.0 dB	1.0 dB
C/Io (at satellite)	64.5 dB/Hz	64.5 dB/Hz

[1] For higher rain rates will use diversity

TECHNICAL CHARACTERISTICS OF THE CONSTELLATION SYSTEM Ka-BAND EARTH-TO-SPACE FEEDER LINKS (NOMINAL)

PARAMETERS	CHARACTERISTIC
1. ORBITAL PARAMETERS	
No. of planes/no. satellites per plane	5 planes-by-8 satellites/plane
Spacing of planes/phasing of planes	
Inclination/orbital period	55/127 minutes
Apogee/perigee	2,000 km/2,000 km
Right ascension/argument of perigee	
2. FREQUENCY BAND	27.5-29.5 GHz (Earth-to-space)
3. CARRIER TRANSMISSION PARAMETERS	
Multiple access technique	FDMA/CDMA (simple frequency changing transponders)
Modulation types/coded data rate	QPSK/direct sequence spread spectrum
Transmit necessary bandwidth per carrier	1.25 MHz/2.5 MHz (S-band service link)
Information data rate	5 kbps with rate-1/2 FEC
Transmit occupied bandwidth per service link spot beam	16.5 MHz
Total assigned feeder link bandwidth	200 MHz (10 S-band service link spot beams and guardbands)
Transmit power per carrier	1 to 10 watts
Earth station EIRP per carrier	62.8 to 72.8 dBW
Maximum carriers per service link beam	50
Required Eb/(No+Io) (and C/(N+I))	2.8 dB (at output of subscriber unit demodulator)
C/(N+I):rain I C/(N+I):clear (including margin)	
Interference criteria (C/Io at satellite receiver)	63.9 dB-Hz
Transmitter noise, C/N	
Satellite receiver thermal noise floor	-197.1 dBW/Hz
Satellite noise temperature	1400 K
4. SATELLITE ANTENNA PARAMETERS	
No. of spot beams/pointing direction from nadir	1 earth coverage beam per satellite/beam points to satellite nadir (i.e. at sub-satellite point)
Transmit peak gain/beamwidth/polarization	3 dBi/97°/CP
Sidelobe mask	ITU Appendix 29, Annex III, D/lambda < 100
No./distribution of transmitting earth stations	Less than 10 within the continental United States; Alaska, Hawaii, Puerto Rico
5. EARTH STATION ANTENNA PARAMETERS	
Minimum earth station antenna elevation/azimuth angle	10° minimum elevation/0-360° azimuth/steerable
Earth station antenna sidelobe	FCC rules §25.209
Earth station transmit antenna gain	63.3 dBi

TRW provided tabular information (in Table 2-1) on its proposed feeder link operations at 29.5-30.0 GHz, and the applicants for the Ellipso and Constellation Non-GSO MSS systems provided the Committee with tabular information on their feeder link parameters if they were required to operate in the 28 GHz band. They are Tables 2-2 and 2-3. Ellipso also provided additional information on its system and Constellation offered a brief report on the results of an interference analysis. However, none of the Non-GSO MSS applicants, other than Motorola, provided a narrative description of their feeder link system. Motorola, however, provided the Committee and its Working Groups tabular information on its feeder links, written descriptions of its system, and analytical techniques for the interference potential between the IRIDIUM feeder links and LMDS systems.

a. IRIDIUM® System and its Gateways and Satellite Control Stations (SCS)

The IRIDIUM system is a satellite-based system which will provide worldwide communications directly from and to handheld and mobile telephone, data and fax terminals. The service will be provided by means of a low earth orbit (LEO) constellation of 66 satellites in 6 polar planes. The system proposes to employ L-Band frequencies for satellite-to-subscriber links while inter-satellite and satellite-to-gateway/SCS communications would use Ka-Band. The IRIDIUM gateways operate in the 29.1-29.3 GHz band and can interface with the terrestrial Public Switched Telephone Network (PSTN) to complete the communications link.

The IRIDIUM system is comprised of three principal elements: the satellite constellation, the handheld/mobile earth terminals (MET), and the gateway/SCS earth stations. The satellites serve as a space-borne switching network linked to each other by intersatellite communications paths, and the PSTN through gateway/SCS communications paths which are capable of providing direct subscriber-to-subscriber links.

The IRIDIUM satellites will employ tracking feeder link antennas with narrow-beamwidths (about 5°) and moderately high gain (about 30 dB) at 30 GHz. These antennas will be directed to track appropriate gateway/SCS earth station complexes. Each gateway/SCS complex will include up to three groups of earth station tracking antennas which will operate to a minimum elevation angle of 5°. Each group of tracking antennas (up to four antennas in each group) will be separated from the other group by up to 40 miles. The separation distance will depend on a number of technical and operational factors, such as local climate conditions, land availability with appropriate zoning, proximity to national and international trunks and switches, etc.

The gateway complex performs several important functions for the system. These include: call set-up and tear-down, billing, satellite tracking, call routing, subscriber location, call hand-over, etc.

Satellite Control Stations will perform all command and control functions for the satellite constellation.

b. Constellation Communications, Inc./Loral QUALCOMM Partnership, L.P./ Mobile Communications Holdings, Inc.

Constellation Communications, Inc. ("Constellation"), Loral QUALCOMM Partnership, L.P. ("LQP") and Mobile Communications Holdings, Inc. ("MCHI") are applicants for licenses to construct and operate non-geostationary mobile satellite systems, pursuant to the cut-off date of June 3, 1991, established by Public Notice dated April 1, 1991 (Report No. DS-1068). Constellation, LQP, and MCHI all applied to utilize frequencies below 15 GHz for feeder links. In its Notice of Proposed Rule Making in CC Docket No. 92-166, the Commission stated that:

> [W]e are preparing to conduct a Negotiated Rulemaking to assist us in assigning the 27.5-30.0 GHz frequency band. We expect, in the context of that proceeding, to be able to identify sufficient spectrum within that band to satisfy the Earth-to-space feeder link requirements of all MSS above 1 GHz applicants that may be licensed in this proceeding. Notice, CC Docket No. 92-166, at para. 77.

As such, the Commission identified Constellation, LQP and MCHI as interested parties in the instant proceeding.

All three applicants are working with the Commission, appropriate other U.S. Government agencies, and within the ITU Radiocommunication Sector to identify appropriate means of utilizing frequency bands below 15 GHz for their feeder links, and are hopeful that these efforts will be fruitful. Nevertheless, Constellation, LQP and MCHI believe that the instant 28 GHz NRM must provide for a rule which would govern sharing between LMDS systems and feeder links used by their Non-GSO MSS systems, in the event the Commission requires the use of spectrum in the 27.5-29.5 GHz band for their systems' feeder links.

SECTION III:

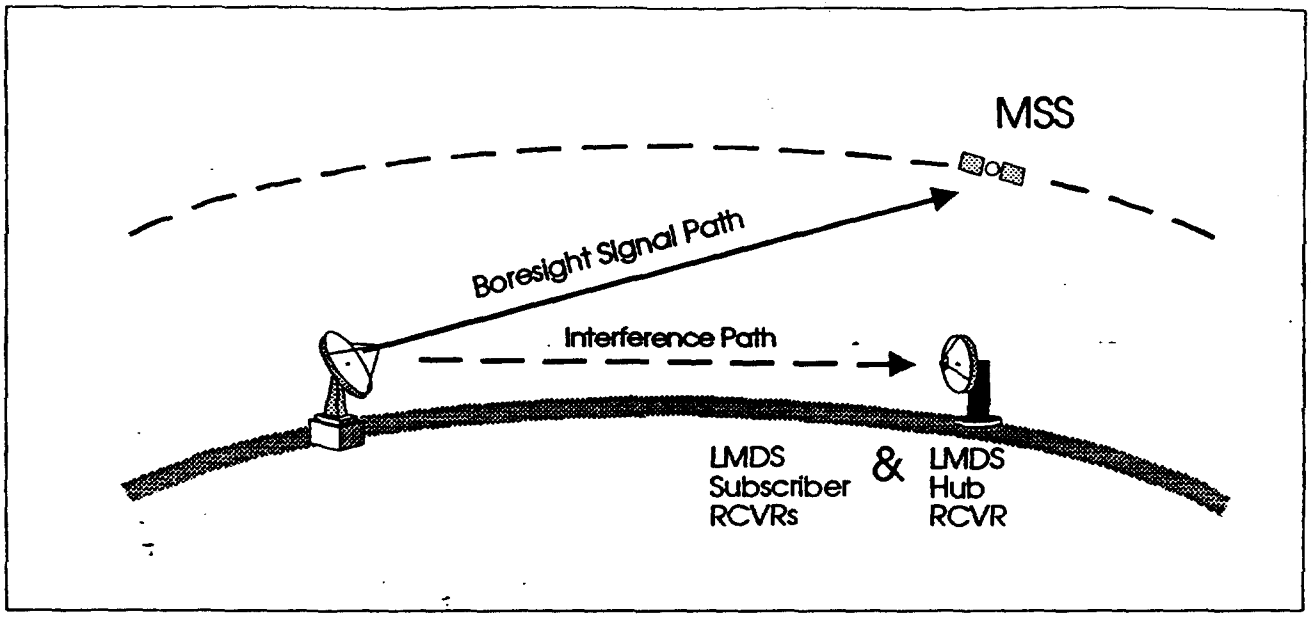
DESCRIPTION OF INTERFERENCE/SHARING SCENARIOS

3.1 Introduction

To address the question of whether Non-GSO MSS feeder links and LMDS systems can share spectrum in the same allocation it is necessary to define the interference/sharing scenarios between the systems to be subjected to analysis. The basic scenarios are depicted in Figure 3-1(a) and 3-1(b).

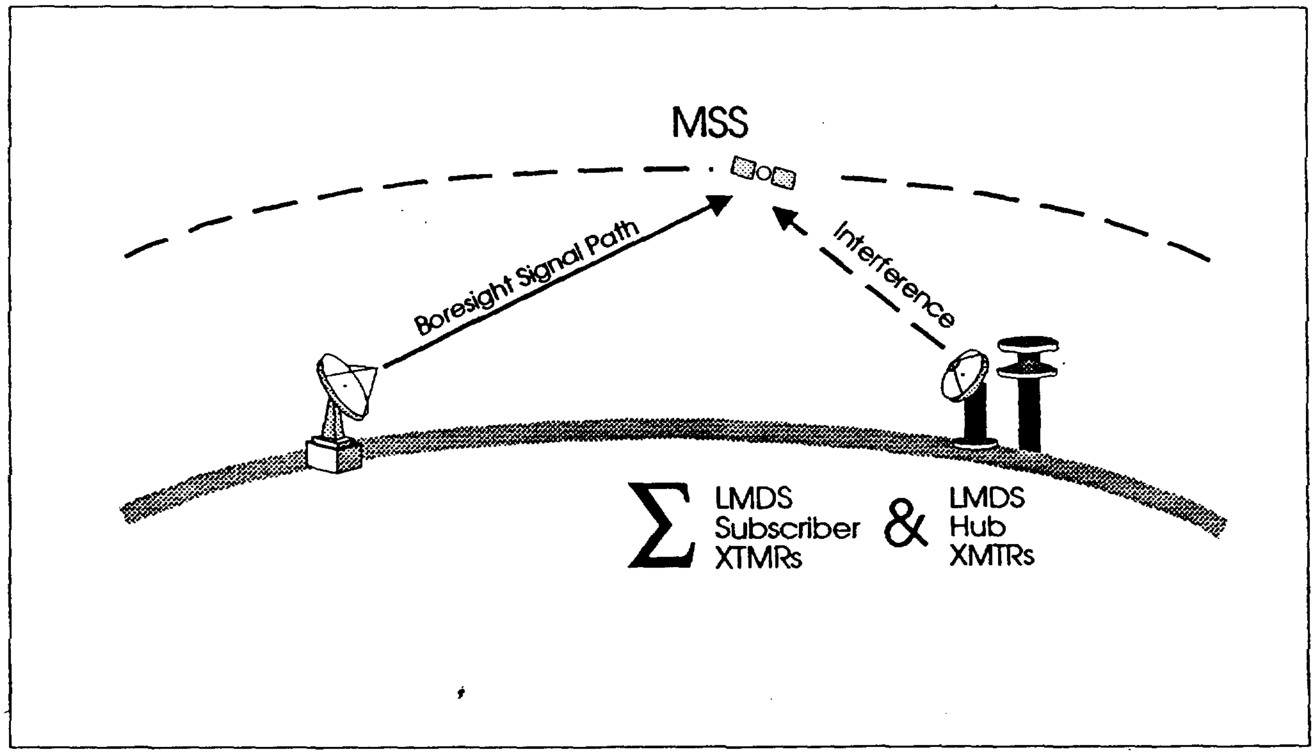
Figure 3-1(a) is the feeder link of the Non-GSO MSS earth station transmitting in the uplink direction to its associated satellite system receivers. These transmissions are a source of potential interference to the different types of receivers of the LMDS system. The proposed feeder link earth stations would transmit at frequencies proposed for use by the LMDS service. They track assorted satellites down to a five degree elevation angle and 360 degrees in azimuth around the earth station site. A Non-GSO MSS feeder link earth station complex can include up to three diversity locations, interconnected, and typically spaced up to 40 nautical miles apart. A typical site configuration is shown in Figure 3-2. Each antenna site must have an unobstructed view at low angles.

The second basic interference/sharing scenario is illustrated in Figure 3-1(b). It consists of the transmissions from LMDS hubs, subscribers and backbone equipment. Each of these transmissions have the potential to cause interference to the Non-GSO MSS satellite receiver. LMDS networks typically have Hub stations transmitting to and receiving from subscriber units located within a distance of a few miles from the hubs. The backbone equipment distributes signals to and from the hubs.



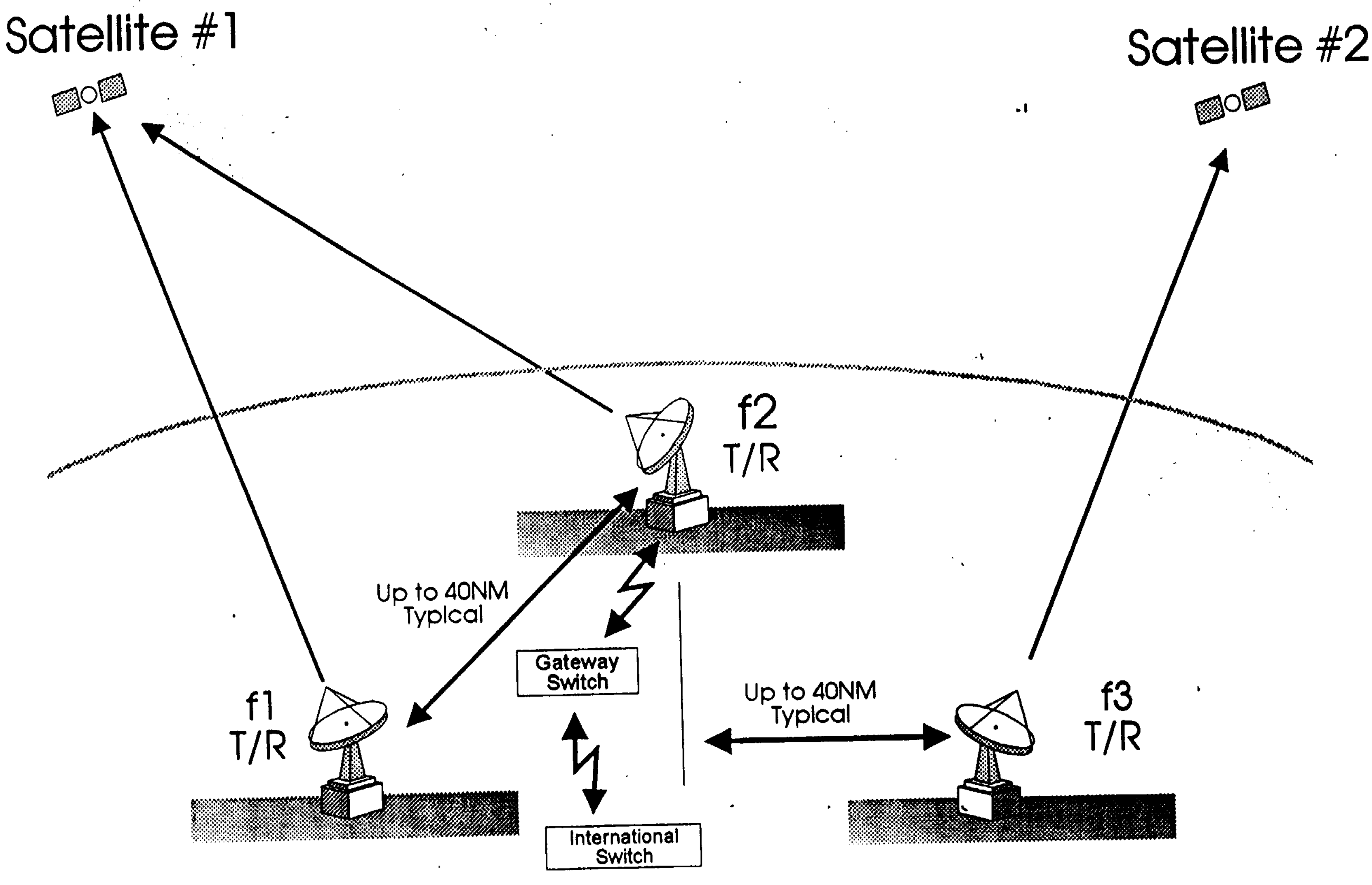
FSS/MSS Non-GSO Feeders into LMDS

Figure 3-1(a)



LMDS into FSS/MSS Non-GSO Satellite RCVRs

Figure 3-1(b)



Typical Non-GSO Feeder Link
Earth Station Complex

Figure 3-2

The following parameters are used in the interference/sharing scenarios:

- **SATELLITE SYSTEM (Non-GSO MSS Only)**

Orbital altitude
Antenna gains and beamwidths
Antenna sidelobe patterns
Antenna boresight elevation angle
System design aggregate long-term interference power allocated for LMDS interference
Earth footprint of the satellite receiver
Peak EIRP density of the feeder link earth station transmitter
Bandwidth
Rain attenuation

- **LMDS**

Hub, subscriber and backbone transmitter power spectral density
Antenna gains and beamwidths
Antenna sidelobe patterns
Antenna boresight elevation or depression angle
Hub, subscriber and backbone density and distribution information
Frequency reuse (e.g. number on frequency)
System design single-entry interference criteria allocated for satellite system earth station interference
Peaking in bandwidth of interest
Cell size
Rain attenuation
Bandwidth
Power control algorithm

3.2 Interference Scenario: LMDS Transmitters Into Non-GSO MSS Feeder Link Satellite Receivers

There are three LMDS components that may cause interference into the Non-GSO satellite receiver. These are the hub transmissions, subscriber transmissions and transmissions from the backbone point-to-point distribution equipment.

The hub and subscriber transmissions are considered as a long term interference while the backbone transmissions may be considered as a short term interference. The interfering power from the hubs and subscribers must be aggregated together to form a long term interfering power into the satellite receiver.

The effect of the LMDS transmissions on the satellite network can be analyzed by evaluating the aggregate interfering power in the satellite receiver from the LMDS transmissions.

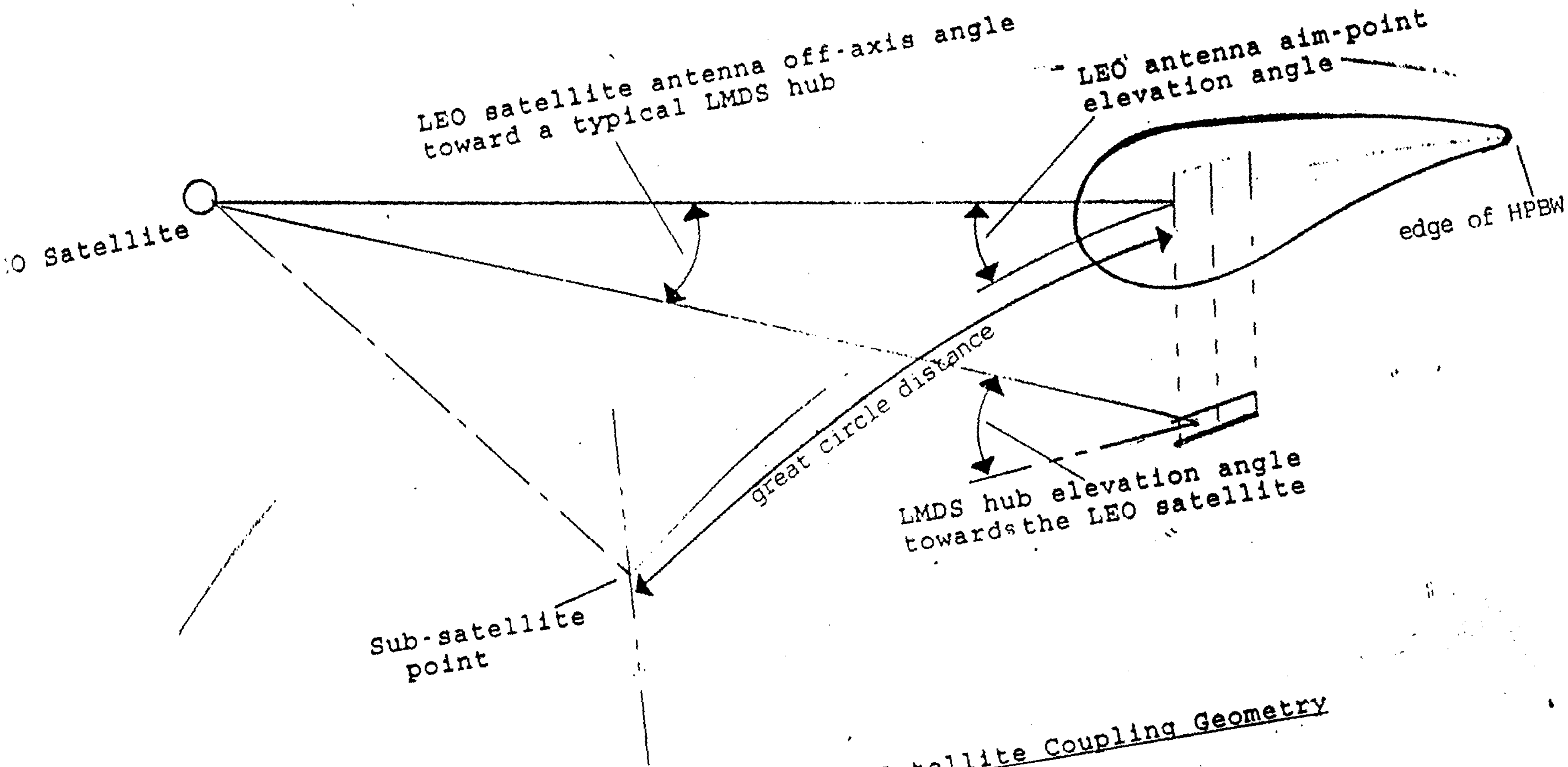
The LMDS hub-to-satellite coupling geometry is shown in Figure 3-3. The coupling geometry for the subscriber and backbone equipment is similar.

3.3 Interference Scenario: Non-GSO MSS Feeder Link Earth Station Transmitters Into LMDS Receivers

The principal interference paths are Line of Sight (LOS). It is those which need to be evaluated to determine the potential for sharing. Figure 3-4(a) and 3-4(b) illustrates the geometric parameters necessary to calculate the potential for interference from the Non-GSO MSS feeder link uplink into LMDS receivers. LMDS hub receivers, subscriber receivers, and backbone receivers may receive interference from the uplink.

There are two geometric parameters that dictate isolation between the Earth station and the LMDS receivers. As shown in the figure, the distance D provides isolation proportional to the distance squared. With both the LMDS receivers and the feeder link antennas elevated above the local ground level, a LOS path will likely exist to the limits of the radio horizon. The second factor is relative elevation of both sites. In hilly or mountainous areas, the feeder link and LMDS sites may be at different elevations. Since the feeder link antennas are tracking antennas, the interference presented to the LMDS system will be a variable depending on the pointing angle of the feeder link antennas.

These interference/sharing scenarios are evaluated in later sections of this report.



LMDS Hub -to- LEO Satellite Coupling Geometry

Figure 3-3

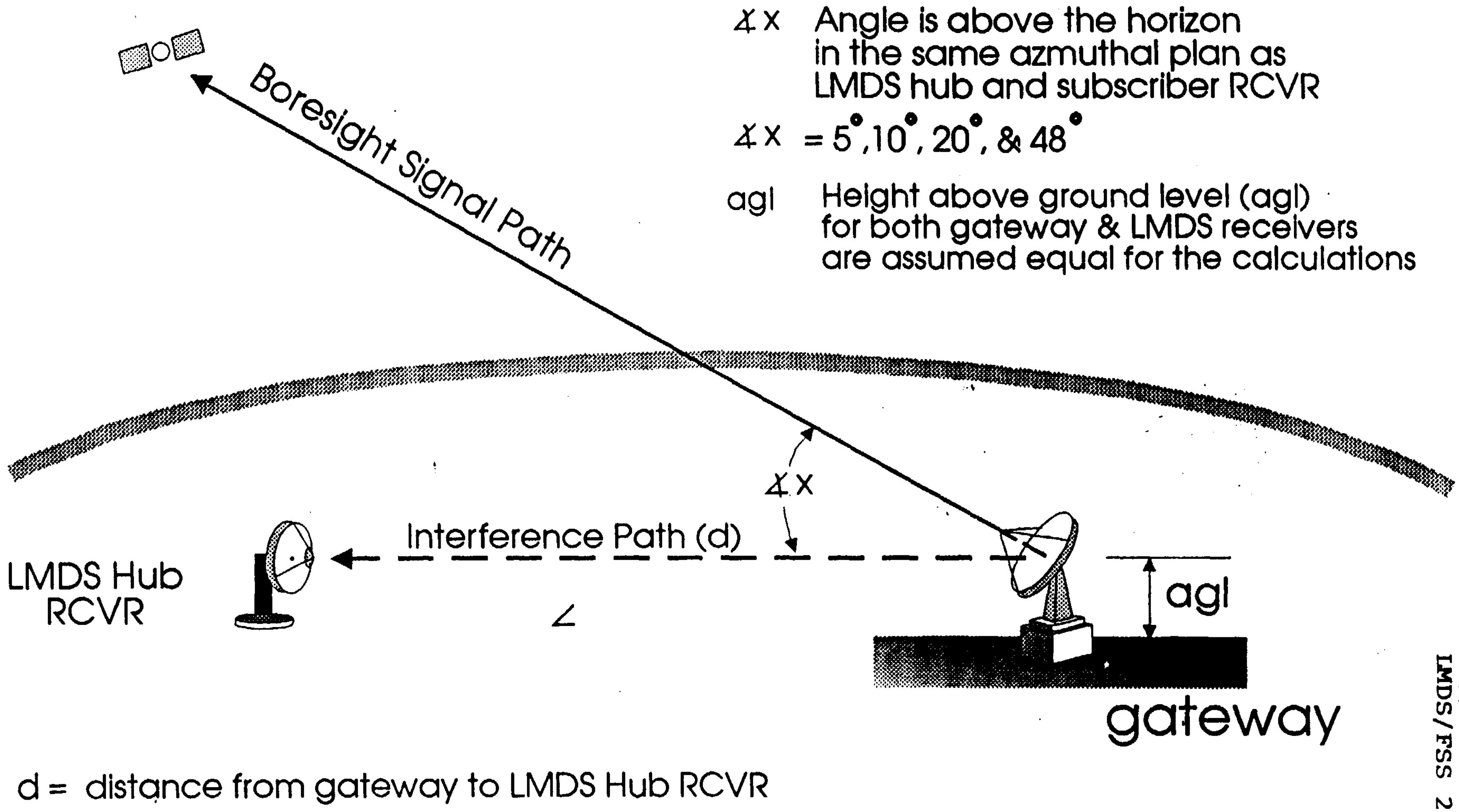


Figure Interference Geometry Defined
Gateway to LMDS Hub RCVR

Figure 3-4a

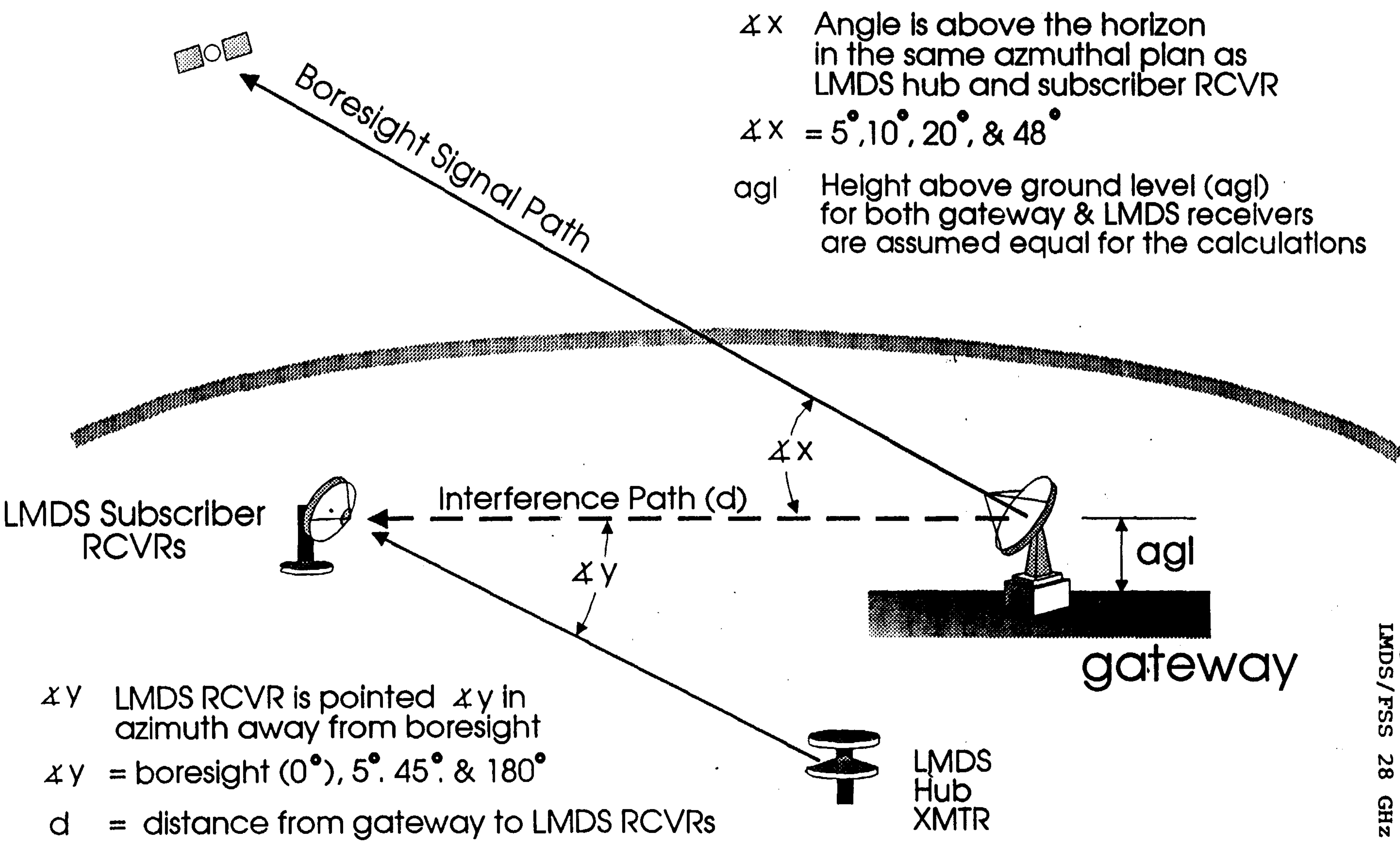


Figure Interference Geometry Defined
Gateway to LMDS subscriber

Figure 3-4b

SECTION IV:

APPLICABLE ANALYTICAL TECHNICAL ANALYSES

4.1 Introduction

In order to perform interference calculations and analysis between Non-GSO MSS feeder links and LMDS terrestrial networks, it is necessary to develop analytical models. Computer based models can handle many complex factors simultaneously, but microwave propagation variables in the earth's atmosphere are statistical in nature and vary substantially depending on particular climatic zone. The United States has a large number of different climatic zones. Therefore, the models must accommodate to some degree the nature of propagation at these frequencies.

The analytical models for the two interference paths of concern are logically quite different. Interference from Non-GSO MSS feeder link stations into LMDS receivers must consider the problem of coupling between earth based stations where the feeder link antenna is continually tracking the satellite for 360° in azimuth and down to as low as 5° in elevation, while LMDS subscriber receivers are oriented 360° in azimuth around LMDS hub stations with narrow beam subscriber antennas pointed at the hub. Also, over-the-horizon interference through tropospheric scattering should be considered.

The model for calculating the second interference path or up link interference into the satellite receiver must consider three different scenarios. The satellite's footprint is quite large, particularly when pointed at a low elevation angle earth station. First, there may be many hubs transmitting co-frequency signals in the wide-beam mode for 360° in azimuth around each hub, but generally downward from the horizontal plane. Second there can be numerous subscriber units transmitting co-frequency signals and their moderate gain antennas are generally pointed above the horizontal plane. Lastly, there can be LMDS stations operating as backbone links to the hubs which have high EIRPs with narrow beam antennas nominally pointing at the horizon but can occasionally vary substantially either side of this plane.

A Joint Technical Sub-Group ("JTSG") was established to determine which propagation factors should be included in the modeling process and was used to the extent summarized in Section 4.1 below. In Section 4.2 the models for calculating up link interference are described, and in Section 4.3 the models employed for calculating interference between satellite feeder link stations and LMDS receivers are described.

4.2 Special Technical Factors

The JTSG made a number of recommendations on special factors to be considered for the specific sharing studies by WG2. These were:

a. Atmospheric Loss

Because up link interference is most severe when the satellite is operating to an earth station at low elevation angles, the clear air loss for different climatic zones can be significant. Table 4-1 summarizes the loss vs. elevation angle at 29 GHz for each of the five U.S. climatic zones. It should also be noted that atmospheric loss is quite significant at lower elevation angles.